FIRE MANAGEMENT NOTES

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FIRE MANAGEMENT NOTES

An international quarterly periodical devoted to forest fire management

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The Cover

Enforcement of laws are necessary to prevent fires when voluntary means fail. Our lead article explains how this was done in Wisconsin with great success.

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State of Wisconsin vs. Railroad Fires

Edward J. Forrester

Railroad operations are annually the largest single cause of forest fires in the State of Wisconsin. In the past 5 years railroads have accounted for from 27 to 47 percent of all forest fires on State and private lands each year.

The railroad companies have traditionally paid suppression costs and damage claims with little objection. However, the companies could rarely be motivated to initiate recommended engine and right-of-way fire prevention work. This situation existed in spite of State-supplied documentation showing that the prevention work would actually cost less than the damages and suppression costs. After a long period of fruitless contacts with railroad officials during 1973, it became obvious that the only available alternative was strong fire law enforcement.

Columbia County, which lies in south-central Wisconsin, was one of two counties chosen for test cases. The counties were selected because they were problem areas and contained willing district attorneys.

Columbia County is traversed by two major railroads, the Chicago and Northwestern and the Milwaukee Road, each of which causes a number of fires annually. The first case was brought against the Milwaukee Road because it had the worst record in the

county, causing an average of 135 fires per year.

The State's strategy consisted of two main points:

First, providing additional documentation to the Milwaukee Road detailing the problems and indicating that all future failures would be prosecuted. Second, prosecution based on the railroad's knowledge of the problem, their knowledge of the solutions to the problem, and their lack of action to correct the problem. The State felt that by proceeding in this manner it would be able to prove negligence on the part of the railroad.

Identification of the problem in ways that railroad officials, defense and prosecuting attorneys, the court, and a possible layman jury could understand was easily solved through the use of cross tabularized fire report data.

With "cross tabs" the State was able to pull out one variable at a time and have the computer prepare a tabulation that could be used to demonstrate key points in the argument.

The initial tabulation demonstrated the railroad fire problems statewide compared to other major causes. It was similar to the one in table 1.

Once this was done, other computer-prepared cross tabs were used to isolate the data for only the Milwaukee Road in one specific country, Columbia.

These tabulations included:

1. Railroad-caused fires, fire size, damages and suppression costs relative to fire numbers, and damages and suppression costs for other major cause categories for Columbia County.
2. Number of rail-road-caused fires, fire size, and damages and suppression costs for each quarter section along the right-of-way. These data were provided for each year and summarized for the preceding 5 years.
3. Number of railroad-caused fires, size, and suppression costs and damages—by hours of the day, by day of the week, and by month of the year.
4. Summary of the number of

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Edward J. Forrester is Natural Resources Specialist III with the Wisconsin Department of Natural Resources in Webster, Wis.

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fires, acres burned, suppression costs and damages caused by the Milwaukee Road in Columbia County during the preceding 5 years.

5. Another tabulation was also prepared by hand showing that when right-of-way work had been done it resulted in very significant fire reductions. Due to the scattered nature of the work, it was impractical to use a computer for this tabulation.

Again, during sentencing, the "cross tabs" data proved its worth. The railroad pleaded for mercy and a minimum fine. However, due to the overwhelming data showing negligence the judge levied the maximum fine for each count.

The most important result of this case was the fact that being brandished a criminal created incentive on the part of the railroad. Therefore, during 1976 they greatly stepped up fire prevention activities.

The outcome of this lengthy process has been an excellent success story. During 1977, the first full year since conviction and since significant railroad fire prevention activities were implemented, only 24 fires were caused by the Milwaukee Road in Columbia County. This reduction from the normal 135 fires occurred in spite of nearly record drought during the first half of the year.

Table 1.—Fire causes statewide.

Statewide data	1972 No.	1972 %	1973 No.	1973 %	1974 No.	1974 %	1975 No.	1975 %	1976 No.	1976 %
Lightning	21	1	13	1	39	2	32	2	72	2
Campfires	35	2	42	2	47	2	69	4	172	4
Smoking	177	10	178	9	229	10	220	11	431	10
Debris burning	287	17	344	18	441	19	413	21	505	12
Incendiary	106	6	237	12	301	13	239	12	535	13
Equipment use	63	4	109	6	186	8	197	10	468	11
Railroads	*802*	*47*	*778*	*40*	*736*	*31*	*479*	*25*	*1,144*	*28*
Children	87	5	97	5	175	7	144	7	288	7
Miscellaneous	143	8	132	7	209	9	157	8	526	13
Totals	1,721		1,930		2,363		1,950		4,141	

Throughout 1974 the railroads were supplied with this type of information along with written requests for compliance with State law. The railroad continued to agree that something should be done but put little effort into fire prevention. Therefore, following the spring fire season of 1975, the State initiated criminal prosecution of the Milwaukee Road on 43 counts.

Once in the court system, copies of the same "cross tabs" data previously provided to the railroad assumed great importance. In fact, due to the quality and quantity of good easily understood data, the defense attorney conceded several key issues during the opening session.

Late in 1975 the railroad was found guilty on all 43 criminal counts and sentencing was scheduled for early 1976.

Recent Fire Publications

Barber, E.H.E.
1977. Report of the board of inquiry into occurrence of bush and grass fires in Victoria. For. Com. Victoria, Melbourne, Australia. 213 p.

Baughman, R.G., and C.W. Schmidt, Jr.
1977. Alaskan lightning storm characteristics. USDA For. Serv. Res. Note INT-235. Intermt. For. Range Exp. Stn. Ogden, Utah. 6 p.

Campbell, R.E., and others
1977. Wildfire effects on ponderosa pine eco-system: an Arizona case study. USDA For. Serv. Res. Pap. RM-191. Rocky Mt. For. Range Exp. Stn., Fort Collins, Colo. 12 p.

National Fire Protection Association
1978. Chemicals for forest fire fighting. Natl. Fire Prot. Assoc., Boston, Mass.

Folkman, William S.
1977. High-fire-risk behavior in critical fire areas. USDA For. Serv. Res. Pap. PSW-125. Pac. Southwest For. Range Exp. Stn., Berkeley, Calif. 12 p.

Gale, Robert S.
1977. Evaluation of fire management activities on the national forests. USDA For. Serv., Washington, D.C. 127 p.

Harrison, H. Ames.
1978. The rural community fire protection program. Fire Command 45 (2): 26-27.

Hunt, Jim.
1978. The Sycamore Canyon Fire. Fire Command 45 (3): 28-29.

Lait, G.R., and S.J. Muraro.
1977. The P.F.R.C. aerial ignition system. Pac. For. Res. Cent., Canadian For. Serv., Victoria, B.C. 27 p.

Lloyd, R.A., A.G. Thayer, and G.L. Lowry.
1978. Pine growth and regenera-

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Analyzing Wildfire Occurrence Data For Prevention Planning

M.L. Doolittle

The data for this article were collected and initially analyzed by Donald a. Nasby, graduate research assistant, Mississippi State University.

One of the conclusions I have reached after a dozen years of involvement in fire prevention research in the South is that fire prevention failures seldom result from lack of information about the fires that occur. A far greater problem is the inability of prevention agencies to process the information so that it is useful in planning and executing prevention programs. In some instances, irrelevant information is collected—it can be seen gathering dust and cobwebs in storage rooms and file cabinets. But in many more instances, useful information goes to waste because of problems in processing or translating it.

Recently, we attempted to assemble some of the kinds of data recommended in *Strategies for Reducing Incendiary Fire Occurrence in the South* (Doolittle, *et al.*, 1976) for a comprehensive fire problem analysis. One of our objectives was to determine how this information, once assembled, could be used in prevention planning. We focused our effort on problem areas in the four Southern States wherein 60 percent of the incendiary fires in the Southern Region (13 States) occur. Problem areas were selected as the unit of study for several reasons:

1. Fire occurrence maps show that incendiary fires tend to occur in rather distinct concentrations or clusters.
2. Field studies and reports by protection agencies have revealed that these problem areas often possess unique characteristics that make them distinct.
3. Focusing upon problem areas rather than entire administrative units or individual fires allows prevention agencies to concentrate their resources.
4. Results of prevention activities in problem areas are easier to see than the same results spread over an entire protection unit.

Assembling the Data

We asked firechiefs in each of the four States for the following information about a representative sample of the incendiary fire problem areas in their States:

1. Size of area protected (acres).
2. Annual fire occurrence for the past 5 years (1971-1975) and causes.
3. Persistence (duration) of fires.
4. Seriousness (cost-plus-loss) of fires.
5. Who owns most of the land in the area.
6. Probable motives for setting fires.
7. Nature of prevention efforts and degree of success.

Information about persistence and seriousness could not be used because of gaps and inconsistencies in reporting. More kinds of data could be gathered in a single protection unit (a State agency or National Forest, for example), but it is processing the information that is the most crucial part of the job. The process we used can be adapted to most situations.

Processing the Information

Our request yielded usable information on 77 incendiary fire problem areas evenly distributed among the four States. Initially we tabulated the reported characteristics of each area (table 1). Then we grouped the 77 areas under each of five characteristics.

Size. The size of the problem areas varied from 100 acres to 138,000 acres, with a mean of 27,000 acres. We established three size categories—small, medium, and large. Since more than half of the problem areas were smaller than the mean, categories do not contain equal numbers:

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M.L. Doolittle is with the Southern Station, Research and Development of Fire Prevention, Starksville, Miss.

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Small (100-11,520 acres) 34 areas.
Medium (11,521-23,040 acres). 15 areas.
Large (⟩ 23,040 acres) 26 areas. (Two areas could not be classified because of incomplete data.)

Incendiary Motives. The fire managers were asked to estimate how many incendiary fires in each problem area could be attributed to these motives: Direct economic gain (to improve grazing or protect property); indirect economic gain (to obtain employment, force land sale, or control pests); and personal satisfaction (grudge, spite, or to force

Table 1.—Arrangement of initial hyothetical data.

Problem area no.	Size (ac.)	No. incend. Fires (1971-75)	Dominant land ownership	Dominant Fire-setting motive	Dominant prevention activity
1	35,000	96	Corporate	Grudge	Personal contact
2	20,000	121	Absentee private	Grazing	Prescribed burning
etc.	etc.	etc.	etc.	etc.	etc.

Incendiary Fire Occurrence. Since nearly 3/4 of the fires in the problem areas had incendiary origins, we chose to rank the areas on the basis of incendiary occurrence alone. In order to compare occurrence among areas of different size, we computed the fire occurrence rate (F.O.R.) for each area (F.O.R. = $\frac{\text{number of incendiary fires}}{\text{acres protected}}$ x 1,000,000). The resulting distribution was:

Low F.O.R. (< 639) 22 areas.
Medium F.O.R. (640-2,207) 28 areas.
High F.O.R. (> 2,207) 25 areas.
(Again, two areas could not be classified.)

Land Ownership. We asked State fire managers to indicate the percentage of each problem area that was owned by the Federal government, State government, corporations, absentee individuals, or other individuals. Areas were then grouped according to the largest landowner class. Only one area was predominantly Federal land, and no area was owned mainly by the State. The three remaining categories had the following distribution:

Corporate .... 41 areas.
Absentee private ...... 11 areas.
Other private .... 24 areas.

agency personnel to work). We also provided "unknown" and "other" categories, which were later grouped with indirect economic gain, with the resulting distribution:

Direct economic gain ... 25 areas.
Personal satisfaction ... 43 areas.
Indirect economic gain and other .... 9 areas.

Prevention Efforts. We asked the fire managers to describe the general and specific nature, duration, cost, and results (successful or unsuccessful) of each prevention effort. We developed a two-way classification based on the dominant activity in each prevention effort and on results (table 2).

Prevention Planning

A particular prevention activity's past performance is the key to its future employment. Personal contact was clearly superior in our 77 problem areas (table 2). But if this were all these data could be used for, the effort spent processing the information would not be justified.

The prevention planner needs to know when and where personal contact (and the other prevention activities) succeeded and the chance of success in future applications. Consequently, we cross-tabulated prevention success with the characterities of the problem areas. We chose to compute ratios rather than frequencies of success (table 3). This was done by dividing the number of successful applications of each activity by the number of applications of that activity reported. (For example, we found that seven law enforcement programs had been applied in small problem areas. Five were reported successful, and two were reported unsuccessful. Therefore, the ratio of success to total applications was 5:7 or .71. (See table 3.) Unknown results were disregarded.

The typical fire problem area in our study contained 27,000 protected acres, the majority of which were owned by a timber company. It averaged 21 incendiary fires per year (an F.O.R. of 778). The majority of

Table 2.—Results of four prevention activities in problem areas

Dominant Prevention Activity	Reported result			Totals
	Successful	Unsuccessful	Unknown	
	- Number of problem areas -			
Law enforcement	5	5	1	11
Prescribed burning	3	9	3	15
Personal contact	13	6	1	20
Other	5	6	1	12
Totals	26	26	6	58

No prevention activity was reported in 19 problem areas.

Table 3.—Ratio of successful applications to number of applications of three prevention activities among categories of problem area characteristics

Categories of problem area characteristics	Prevention Activities		
	Law enforcement	Prescribed burning	Personal contact
		- Ratios -	
Size			
Small	.71	.29	.71
Medium	0	0	.67
Large	0	.25	.67
F.O.R.			
Low	.33	.25	.75
Medium	.33	0	.50
High	.75	.50	.80
Ownership			
Corporate	1.00	.50	.62
Absentee private	1.00	.33	75
Other private	0	0	.71
Motives			
Direct economic gain	0	.25	1.00
Personal satisfaction	.71	.29	.73
Indirect economic grain & other	0	0	.33

fires were apparently set because of grudges against the corporate landowner. In terms of the categories we established, the typical problem area is large and has a medium F.O.R. It is corporate in ownership and the main fire-setting motive is personal satisfaction. The question we want to answer is, "Which prevention activity has performed best in the past in problem areas like this?" The answer can be derived by adding the ratios corresponding to the four concentration characteristics for each prevention activity. Law enforcement is 0 + .33 + 1.00 + .71 = 2.04. Prescribed burning gets a .25 + 0 + .50 + .29 = 1.04. Personal contact is .67 + .50 + .62 + .73 = 2.52. Our conclusion is that personal contact prevention programs have the best record in this kind of problem area with law enforcement a close second. This procedure could be followed for any type of area for any number of characteristics or prevention activities.

Wildfire Coordination In Colorado

Al Duhnkrack

The wildland fire protection agencies in Colorado have recently joined forces in a statewide effort to assist one another in their fire management efforts. The resulting cooperating unit is called the Colorado Wildfire Coordination Group.

This Coordination Group was formed in April 1977, primarily because of the concern over the need for stronger fire prevention efforts in Colorado's Front Range—with its coexisting urban developments and insect-killed forests—and the anticipation of a potentially devastating drought-related fire season.

Purpose

Its purpose is to improve the capability, effectiveness, and efficiency of all Federal, State, and county rural wildfire protection agencies in the State. The group serves as a forum for the agencies with individually unique fire control programs, but with similar objectives in wildfire management, for the mutual benefit of all parties.

The Group's role is one of coordination rather than direction. Individual agency representatives implement group recommendations through regular agency program budgeting and administrative channels. The group forum provides a means for coordinated actions that did not exist previously.

Membership

The membership consists of State-level representatives of the Colorado State Forest Service (CSFS); Aviation and Fire Management, and Cooperative Fire Protection, Rocky Mountain Region, Forest Service (USFS); Denver Regional Office, National Park Service (NPS); Bureau of Land Management (BLM); Bureau of Indian Affairs (BIA); Colorado State Division of Disaster Emergency Services; and the National Weather Service.

Some of the Group meetings are also attended by Colorado Division of Local Government, Colorado Fire Service Training Manager of the Community College System, and Colorado Division of Wildlife.

Problems

Most of the wildfire problems in Colorado stem from the forest types and the brush and grass cover types that are found in the Rocky Mountains and in the foothills east and west of the Continental Divide. Under normal weather conditions, wildfire is a threat during the dry periods in early spring, late summer, and fall. Midsummer rains help to reduce the hazard during July. The occurrence of either lightning or human-caused fires in hazardous fuels during dry, windy

Al Duhnkrack is Director of Aviation and Fire Management, Rocky Mountain Region, USDA Forest Service, Denver, Colo.

periods may result in rapidly spreading fires. Much of the east side Front Range lands contain high-value homes. This combination of circumstances leads to a classification of high value, high risk areas.

In Colorado, the fire control job on lands of all ownership (36 percent Federal, 64 percent State and private) involves attack on more than 1,500 wildfires on forest and range lands each year. Statewide, the percentage of human-caused fires is 63 percent, compared to 37 percent lightning caused fires. Human-caused occurrence ranges from 88 percent on protected private and State lands to 39 percent on National Forest lands and BLM lands.

Fire protection on these forest lands and associated grass and brush cover areas is provided by Federal agencies, by the State of Colorado, and by 277 rural fire departments which implement the fire protection responsibilities of the county sheriffs on private lands.

Achievements

Achievements of the Coordination Group have already been realized this year. Some are discussed below.

- A prevention working team, under the chairmanship of Bill Graepler, CSFS, coordinates joint news releases and prevention messages. The team also works up an inseason weekly prevention news release showing the number of fires, acres burned, fire causes, and any fire restrictions, along with a specific prevention message for special problem areas.
- The prevention team worked on guidelines for fire restrictions and closures covering all lands in the State. The guidelines stipulate burning conditions, manpower availability, and frequency and number of going fires before agreed-to restrictions are imposed by each agency. A State coordinator is also named to assure agency consistency with the restrictions.
- A training team chaired by Hugh McLean, USFS, coordinates all fire training efforts of the various agencies. Course assignments are made to each agency, and attendance and instructor job loads are shared.
- The Group has realized other benefits, such as the pooling of overhead fire team organizations. Two class I and one alternate inter-agency overhead teams exist and share season-long, oncall duties. There will soon be additional class II teams formed to cover smaller fire situations, one team on the Front Range and another on the West Slope of the State.
- All 15 category I and category II crews are coordinated and dispatched jointly to going fires. Two standby air tankers, one FS and one BLM, cover the State, and the four helicopters, one FS and three BLM, are used jointly as needs dictate.
- All statewide fire weather stations have been reviewed and distribution changes made to fill any voids so that Fire Weather Forcaster Walt Wade can provide more accurate forecasts.
- Physical fitness and qualification standards for firefighters are accepted by the group, and training and experience programs are designed to keep up the standards of the fire organizations. It is the usual practice to fill overhead positions on a project fire with a qualified individual and a trainee.

Future Plans

Future plans include:

1. A review of the agency protection responsibilities and the exchange of protection in certain areas of the State where duplicate and overlapping jurisdictions exist.
2. The formulation of smaller multicounty interagency working groups that can coordinate local suppression and prevention actions. The Northern Forest Range Alliance is a working example of such a smaller working group. This Alliance was formed in 1974 through the leadership of "Sonny" Stiger, USFS, and Ron Zeleny, CSFS.
3. A look at ways to improve communication systems and to establish an interagency fire center, complete with cache and coordinated dispatch capability for the West Slope at BLM's fire control facility at Grand Junction Airport. East side dispatcher office and fire cache will be housed in the Denver area. Any large statewide wildfire emergency situation will be coordinated from the State Disaster Center at Camp George West, near Denver.

As fire management practices advance, along with the opportunities for the prescriptive use of fire to achieve our land management objectives, we can foresee a need to interact, exchange ideas, and share our professional expertise.

Synergy Exists

While Colorado's wildfire control situation may not be as complex as many other western States, the Group believes that the enthusiasm of its protection agencies to help each other is unsurpassed.

The interaction of this Group produces a synergy, resulting in new ideas and better ways to partnership the total fire job.

There is also a strong feeling of accomplishment. Group members all realize and know they can do their job more effectively, keep the wildfires smaller, and reduce the number of ignitions.

One can also sense a feeling of confidence among the Group that the members can now collectively handle any wildfire emergency.

FIRE MANAGEMENT

National Fire Danger Rating Update—1978

James E. Hefner
John E. Deeming

The history of formal fire danger rating can be traced back to the early 1920's. It was recognized as early as 1940 that a system was needed that could be applied nationwide. In 1958, a joint committee composed of fire research and fire control personnel agreed that a national system was feasible. By 1961, the basic structure of a four-phase rating system had been outlined and the first phase, the spread phase, was ready for field testing. In 1964, the Forest Service Handbook (FSH 5109.11) covering the spread phase was issued for field use.

With publication of USDA Forest Service Research Paper RM-84 "National Fire Danger Rating System" in February 1972, the pre1978 National Fire Danger Rating System (NFDRS) was released for implementation and soon became operational. At that time it was anticipated that new research knowledge and field experience would highlight some areas where improvement to the system could be made.

Since 1972, the system has been used extensively by all Federal agencies and approximately 35 State agencies charged with forestland and rangeland fire protection. During the summer of 1976, for example, data from more than 800 stations were processed through the interactive computer program AFFIRMS, while data from 1,200 stations were processed manually each day.

The 1972 system was updated under the direction of a technical committee chartered in 1974 by the Chief of the Forest Service. The NFDRS Technical Committee membership was made up of Forest Service Research and National Forest Systems personnel; fire managers from the Bureau of Land Management; and the States of North Carolina, Pennsylvania, and Oregon.

The implementation of the 1978 revision of NFDRS was under the direction of the National Wildfire Coordinating Group (NWCG) NFDRS Implementation Working Team. This team is composed of fire managers from Forest Service Research, National Forest System, and State and Private Forestry; BLM; Bureau of Indian Affairs (BIA); and the States of Texas and North Carolina.

Implementation

Let's look at what this update of the 1972 system means to the user. There has been a sincere attempt to minimize the impact of the updating implementation. The terminology has not changed and neither has the required observational data. The fire weather forecaster is not being asked for any additional items.

With the 1978 revision the *numbers* are different and the lack of a defined upper limit for the index scales may be troublesome for awhile. However, once the manning-level definitions are updated and the historical maximum values are defined by the use of the program for analyzing historical fire weather data (*FIRDAT*), things will smooth out. *FIRDAT* has been updated and is now operational on the USFS Univac System at Fort Collins.

For those not using the computer program *AFFIRMS*, the calculations are more involved than in the 1972 version. The 1,000-hour timelag fuel moisture and the live fuel moisture must be calculated. In these, as with other calculations, nomograms are used instead of tables so that the results will better match computer-produced ratings. The AFFIRMS program and the manual system, using nomograms, have both been constructed with "dual" English/metric scales to handle metrication once it becomes official.

The 1978 NFDRS is presented in two publications that take the place of RM-84:

> Deeming, John E., Robert E. Burgan, and Jack D. Cohen, 1977. The national fire danger rating system—1978. USDA Forest Service General Technical Report INT-39.
>
> Burgan, Robert E., Jack D. Cohen, John E. Deeming, 1977. Manually calculating fire danger rating, 1978 national fire danger rating system. USDA Forest Service General Technical Report INT-40.

These publications are available from the Intermountain Forest and Range Experiment Station, Ogden, Utah.

James E. Hefner is the National Fire Danger Rating Specialist, S&PF Liaison Office, Boise Interagency Fire Center, Boise, Idaho.

John E. Deeming is Project Leader, NFDRS Research Work Unit, Northern Forest Fire Laboratory, Missoula, Mont.

NFDRS Development Summary

The following is a summary of tasks to be undertaken to update the NFDRS:

1. Improve the response of the NFDRS to drought.
2. Increase the sensitivity of the ratings, especially in the lower fire danger ratings.
3. Improve the parameters of the existing fuel models and construct additional fuel models where needed to provide better fuels resolution.
4. Redevelop the fire occurrence module.
5. Improve the capability of the NFDRS to reflect the effect of decreasing burning period on fire danger during the fall (seasonality).
6. Increase the range of slopes considered.

Response to Drought

Because the largest fuel considered in the 1972 NFDRS has only a 100-hour timelag, the indexes did not respond to long periods of below average precipitation.

The most logical response to such events is a drop in the moisture content of the live fuels—herbs, forbs, and the twigs and foilage of woody shrubs species. In addition, it was determined that the inclusion of dead fuels up to 6 inches in diamenter (1,000-hour timelag class) could be justified for some fuel models.

Predictive equations for the 1,000-hour timelag fuel moisture and for the live fuel moisture were developed and incorporated into the system.

Rating Sensitivity

The lack of sensitivity of the 1972 NFDRS indexes and components to changing conditions has caused many users to misjudge the NFDRS. This is unfortunate because the problem was caused by poor choice of scaling factors, not by shortcomings in the basic, underlying theory.

The problem has been solved by making the scales for the fire behavior components open ended. The spread component (SC) is numerically equal to the predicted *ideal* rate of spread in feet per minute, and the energy release component (ERC) is numerically equal to the predicted available energy units of 25 BTU's per square foot. Each unit of burning index (BI) equates to 0.1 feet of flame length (a BI of 100 indicates an ideal flame length of 10.0 feet).

These changes will result in a three-to-five-fold increase in sensitivity of the BI and SC. The sensitivity of the ERC will be about the same as in 1972, but it can range above 100 in some fuels when the conditions are particularly severe.

The fire load and occurrence indexes and the ignition and risk components will continue to be expressed on a 0 to 100 scale.

Fuels Models

In the 1972 NFDRS, the user was given a choice of nine fuel models. For the 1978 revision the selection of fuel models has been expanded to 20. These fuel models are listed in table 1.

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Table 1.—The 1978 fuel models.

Grass and grass-like	
Western annual grass	A*
Western perennial grasses	L
Everglades sawgrass	N
Tundra	S
Savannah	
Open timber with grass	C*
Brush	
Sage-grass	T
Mature California chaparral	B*
Intermediate chaparral	F
High pocosin	O
Southern rough (palmetto-gallberry)	D*
Timber	
Short-needled conifer heavy dead	G*
Short-needled conifer normal dead	H*
Western long-needled conifer normal dead	U
Southern pine plantations	P
Alaskan upland black spruce	Q
Hardwoods summer	R.
Hardwoods winter	E*
Slash	
Heavy	I*
Medium	J
Light	K

*The models carried over from 1972 NFDRS.

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Occurrence Modules

Because of the dissimilar character of human-caused and lightning-caused fires, they are best considered separately. Hence the structure of the occurrence module has been modified to provide separate occurrence indexes for human-caused and lightning-caused fires.

Both occurrence indexes incorporate factors that scale the output to local fire occurrence experience. The result is a pair of indexes with improved capabilities to predict fire occurrence levels.

Human-Caused Fire Occurrence Index (MCOI). The MCOI is derived from the human-caused risk (MCR) and the ignition component (IC). The MCR appears essentially the same as in the 1972 NFDRS. However, it incorporates factors derived from local fire records.

The IC has been considerably modified and its definition made more specific. For the 1972 NFDRS the IC was defined as "a number related to the probability that a firebrand, introduced into fire fuels, will produce a successful ignition." For 1978, "successful ignition" has been changed to "reportable fire." Because of its importance in determining whether or not a fire will require suppressive action, a consideration of the potential fire spread has been included.

Lightning-Caused Fire Occurrence Index (LOI). The LOI, like the MCOI, is derived from the IC and an assessment of lightning incidence, lightning risk (LR). LR is calculated from the lightning activity level (LAL) and the LR scaling factor.

The LR scaling factor is derived from local records of thunderstorm days and lightning fires. Its function is to localize the model predictions by "adjusting" the assumptions concerning the fire setting efficiency of lightning discharges. The LR scaling factor statistically "lumps" local fuel, topographic, and thunderstorm characteristics not addressed directly by the basic model.

Six LAL's are used. LAL's 1 through 5 are essentially the same as in the 1972 NFDRS. LAL 6 was added for "red flagging" exceptionally dangerous situations.

Seasonality of Ratings

The 1972 NFDRS tends to overrate fire danger during the late summer and fall. The Canadians account for the seasonal variation of insolation and the resulting effects on the moisture exchange processes. But up to this time we have not.

We have accounted for this effect in several ways. First, in the calculation of the moisture contents of the 100-hour and 1,000-hour timelag fuels, instead of a simple average of the 24-hour maximum and minimum equilibrium moisture contents, a weighted average is used to characterize the drying "power" of the day. As the period of daylight shortens, the nighttime conditions are given increasing weight, thus promoting moisture recovery in the heavy fuels.

Second, a fuel moisture analog (½-inch stick) is being used to determine the 10-hour timelag fuel moisture value. An analog is by far the simplest approach because all of the seasonal associated influences are automatically incorporated in the fuel stick response.

Insufficient Terrain Definition

In the 1972 NFDRS, three slope classes were used: 0-20 percent, 21-40 percent, and 40+ percent. This was not sufficient for mountainous areas where slopes up to 100 percent are encountered.

The number of slope classes has been increased to five with 90 percent the midpoint of the last slope class. The classes were selected so that the effect of slope doubles if the next higher slope class is used. In other words, slope class 5 will have 16 times the effect on spread as slope class 1.

Fire Behavior Components and Indexes

We had no basis for suggesting changes in the ways the SC and BI are derived. The SC is directly related to the expected forward rate of spread, and the BI is directly related to the expected flame length. We have made changes in the computations of the ERC and FLI and have reassessed the way the BI should be interpreted.

The Burning Index (BI). For the 1972 NFDRS it was postulated that the effort required to contain a fire was proportional to the length of flames at the fire's head. Later studies indicate that the containment difficulty is more linearly related to the fireline intensity as defined by Byram. Byram related flame length to fire line intensity, and since the BI is related to flame length, a relationship can be derived between the BI and fireline intensity. What this has shown is that the containment job increases at more than twice the rate of the BI.

The Energy Release Component (ERC). The 1972 ERC was derived from Rothermel's reaction intensity which has the units BTU/ft^2/minute. It implies a measure of intensity because of the time unit. However, it is misleading since the tendency is to equate it with Byram's fireline intensity which it is not. It was found that the reaction intensity calculated for the 1978 fuel models did not rank the fuel models logically, the problem being that the reaction intensity is a function more of the surface area-to volume ratio and bulk density than of loading.

A more intuitive basis for the ERC is available energy per unit area. Such a parameter is easily derived by multiplying the reaction intensity by the residence time. Each unit of ERC equates to 25 BTU's of available energy per square foot.

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History of NWCG

Jack Wilson

The National Wildfire Coordinating Group (NWCG) was established officially in a Memorandum of Understanding, signed in 1976, between the Secretaries of Agriculture and the Interior. Its stated function and purpose is:

> "To establish an operational group designed to coordinate programs of the participating agencies so as to avoid wasteful duplication and to provide a means of working together constructively. Its goal is to provide more effective execution of each Agency's fire management program. The Group provides a formalized system to agree upon standards of training, equipment, aircraft, suppression priorities, and other operational areas."

Agreed-upon policies, standards, and procedures are implemented directly through regular agency channels.

What preceded achievement of this highly desirable objective? How was it done?

Need

Over the years there had been a long recognized need for wildfire coordination expressed by the top administrators in government. The costs of fire programs and the similarity of action taken by several agencies involved in fire activities were evident.

In 1970

The beginning of NWCG is usually traced to an option paper requested by the Secretaries (Hardin and Morton) in 1971, after the disastrous California and Washington fires in 1970. The options ranged from "leave well enough alone" to a centralized fire force. The most acceptable first step was to establish a group to identify and coordinate matters of common interest that could be agreed upon.

Prior to 1970

NWCG, or at least the concept, really came from much further back. Part of it began in 1943 when a very far-sighted agreement was signed by Secretaries Harold L. Ickes, U.S. Department of the Interior (USDI) and Grover B. Hill, U.S. Department of Agriculture (USDA), who directed their agencies to coordinate and cooperate in the areas of fire activity. Part of it came from the Boise Interagency Fire Center (BIFC) concept that began in the early 1960's; but a lot of the same cooperative thinking has been in the minds of many field people for many years because they could see the duplication, waste, unnecessary effort expended, and costs of every agency doing it alone. Historically, effective cooperative effort is spotty, but these efforts have been around a long time.

First Step

The first step was taken on January 24, 1973, in the auditorium on the eighth floor of the Department of the Interior building. A meeting was held to explore developing an effective cooperative concept.

In attendance were Henry W. DeBruin, USDA Forest Service, representing the National Forest System; Jack F. Wilson, USDI Bureau of Land Management Director BIFC; Willard Tikkala, Forest Service, representing State and Private; Richard Ely, USDI Bureau of Indian Affairs; Robert Bjornsen, Forest Service Director BIFC; Roger Gettings, USDI National Park Service; Craig Chandler, Forest Service, representing Forest Fire and Atmospheric Sciences Research; James Richardson, Bureau of Land Management; and James Hubert, USDI Fish and Wildlife Service.

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Jack Wilson is the Bureau of Land Management Director—Boise Interagency Fire Center, Boise, Idaho.

NWCG
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The musty, low ceiling, dark panelled, cold room portended an ominous session. Agency representatives were at first hesitant to vary from their traditional roles. After several hours, H.W. DeBruin stepped forward to moderate the session and began to draw forth the expectations from the participants and to identify areas where all could benefit from coordination.

Scope and Role

The scope of the group was examined and some important and exciting roles were agreed to that chart the NWCG course to this day:

1. NWCG must focus on the future and not get bogged down in current problems and details.
2. NWCG must serve as a focal point for wildland fire management.
3. NWCG must recognize the importance of the States' roles.
4. NWCG must represent the wildland fire segment as the National Fire Prevention and Control Act is implemented.
5. NWCG must recognize the conflicts and resolve them as an integral part of effective interagency coordination.

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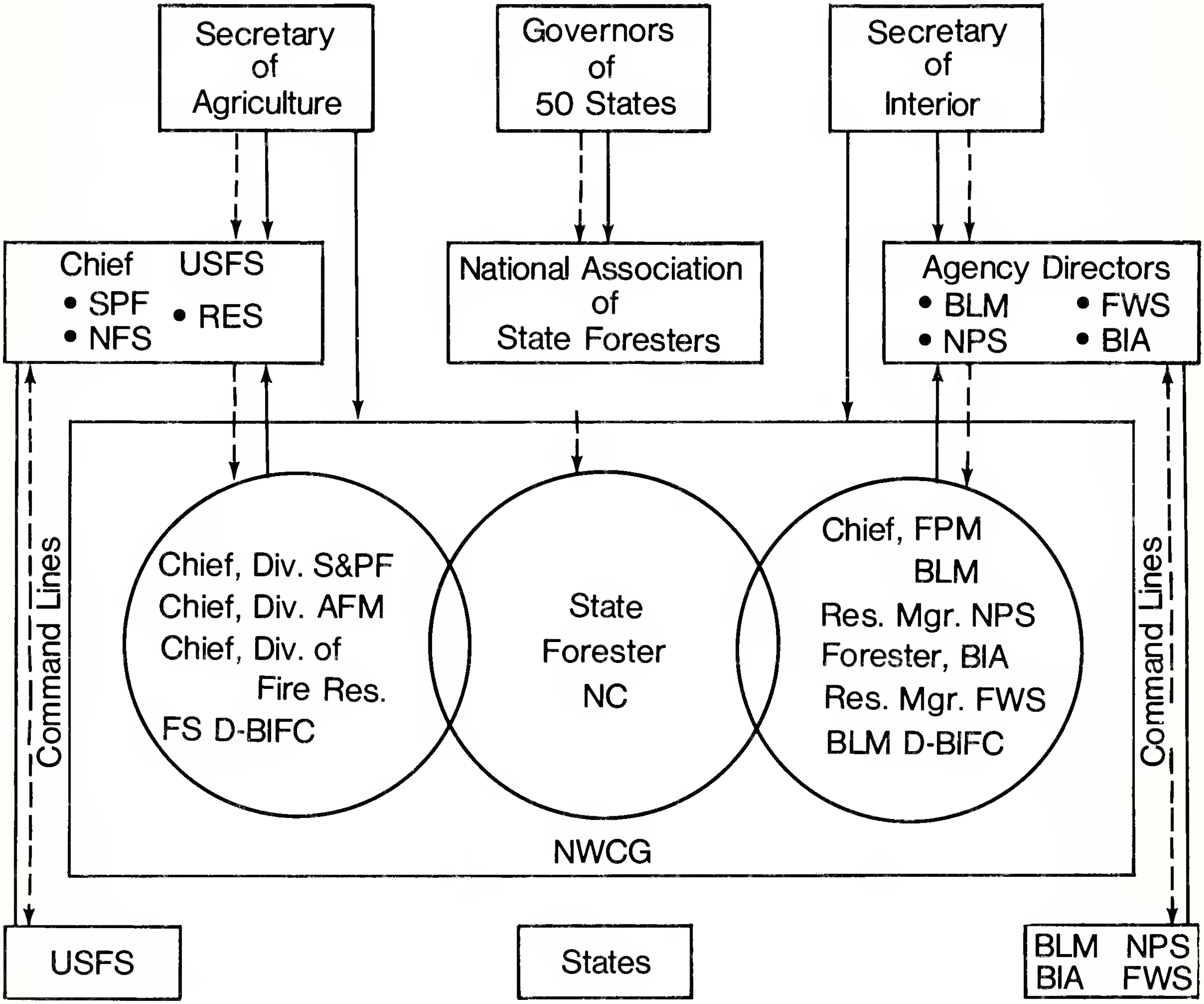
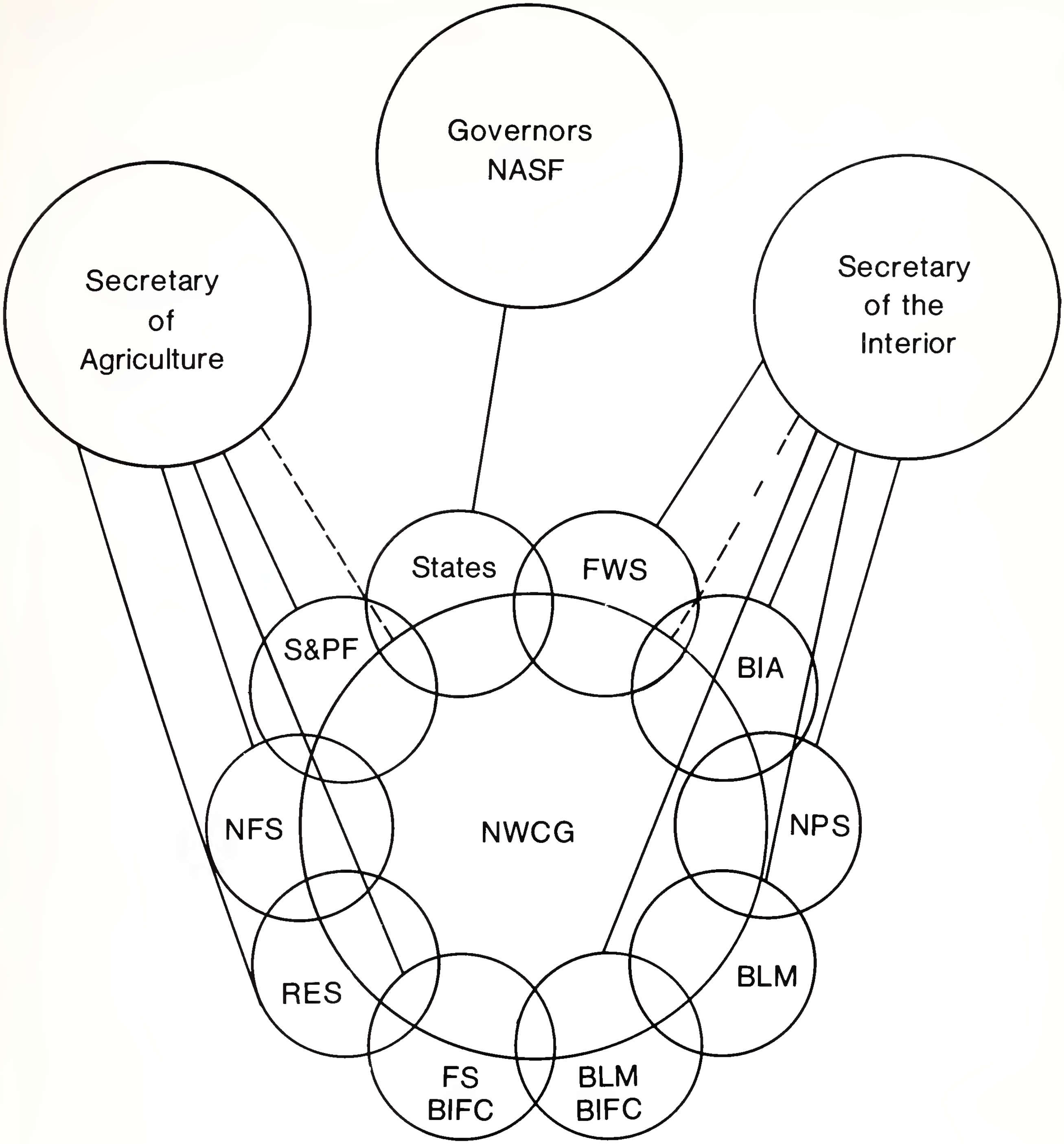


Field Units



Synergism of NWCG

Name

A great deal of time was spent selecting a name for the group. It was unanimously agreed upon to accept as the name National Wildfire Coordinating Group. The Group felt that each word of the name was significant and it was adopted because the perceived roles and assignments were inherent in the name.

Charter

It was agreed that a charter signed by the Secretaries of Agriculture and the Interior would maximize NWCG effectiveness. The charter's contents were considered and an outline adopted.

Working Teams

Working teams were decided upon as the most effective way to meet the needs and constraints of the NWCG. Ten working teams were established. The five ad-hoc teams were: Qualifications and Certification, National Fire Danger Rating System Implementation, Air Operations, Agreements, and Retardants. The five standing teams were: Training, Prevention, Communications, Research Needs, and Safety.

Charter Approval

The next meeting was held in Rosslyn, Va., March 12 and 13, 1974. With this meeting began the long effort to obtain charter approval through the Secretaries of Agriculture and the Interior. This goal was achieved March 16, 1976.

State Representative

An important tenth member, the state representative, was appointed during the March 1974 meeting, and Ralph Winkworth of North Carolina joined the NWCG at Rosslyn in the first 1975 meeting.

Accomplishments

Since that beginning 5 years ago, the benefits of cooperation and coordination have begun to flow. Just to list a few:

—A National Qualification and Certification System Suppression Training Curriculum

—A Fire Management Seminar for top-level line managers at Pajaro Dunes, Calif.

—A National Fire Equipment Identification System (NFES)

—Two tested and approved long-term retardants

—A nationally applicable Fire Danger Rating System (NFDRS)

—Standard aviation contracts for USDA, Forest Service and USDI, Office of Aircraft Services.

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The Fire Load Index (FLI). The FLI is the culminating index of the NFDRS. It is designed to combine the projections of fire occurrence and behavior into a single number that *can* be related to the total fire control job. For 1978, the FLI will be calculated so that it will not be penalized for either low OI's or low BI's. The FLI ranges over a scale of 0-100. By itself, the FLI does not tell much about the nature of the fire management problem. To get a complete picture, one has to examine the components and indexes that are the basis for the FLI.

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Fire in Nebraska?

Robert W. Tice

Most individuals, even those familiar with the USDA Forest Service's far-flung fire management responsibilities, are surprised to learn that fire is a major consideration for the Forest Service in Nebraska's Pine Ridge country. A major fire, The Cunningham Fire, covering over 2,600 acres occurred in September 1976, in this State known for its tall corn instead of pine trees.

Area Described

Much of Pine Ridge is included within the Nebraska National Forest, but only 36 percent of the land within the exterior boundary is federally owned. State ownership totals 4 percent and private inholdings account for 60 percent.

Pine Ridge is a crescent-shaped escarpment, anchored at the tips near Kyle, S.Dak., and about 15 miles north of Lusk, Wyo., and sweeping southerly in an arch passing 5 to 15 miles south of Chadron and Crawford, Nebr. It varies in width from a few miles to 25 miles and ranges in elevation from 3,500 to 4,500 feet. The topography is rough and characterized by sharp ridges and steep canyons with numerous sandstone buttes and outcroppings. Native ponderosa pine covers this escarpment.

Annual precipitation fluctuates from 9 to 36 inches with an average of 17.19 inches, most of which occurs from April to September. Temperatures range from a minus 37°F to 111°F. Prevailing winds are from the northwest and characteristically dry. Afternoon and evening thundershowers are common in the summer.

Fire History

Fire is a natural part of the ponderosa pine type found on the Pine Ridge. Until the settlement of the area by people of European extraction, periodic surface fires thinned the forest and kept reproduction at a minimum. With fire control, first by the early settlers and eventually the Government, wildfires have become less extensive.

These control efforts have resulted in stands containing dense ponderosa pine reproduction, which—with increased accumulations of dead fuel —provide a ladder for fire to reach the tree crowns.

The danger of crown fire is now much greater than it was 70 years ago when the stands had a predominately grass understory. Timber cutting on the private inholdings where slash is not disposed of increases fuel accumulation.

District Fire Job

There have been two large fires in the area since 1960. Large and disastrous fires are quite common in the surrounding grassy plains. This was demonstrated by the 18,740-acre Plum Fire of 1965 and the 100,000-acre Mullen Fire of 1972. In each case, volunteers responded readily. Volunteers and equipment from up to 100 miles away have rushed to battle the fires. In each case the lack of communication between units resulted in some wasted effort. The lack of people trained in large fire command, service, and plans functions has limited fire control efforts.

Usual Procedure

The Pine Ridge Ranger District averages eight fires on National Forest lands per year. These are predominately lightning fires. The District has had two class D and two class F fires during the period from 1971 through 1976. (Class D fires range in size from 100 to 299 acres and class F from 1,000 to 4999 acres.)

Detection is provided by Forest Service air patrol, permittees, and residents. The fact that initial attack begins on most fires while they are small shows the effectiveness of this system.

Initial attack is usually handled by either the Chadron or Crawford Volunteer Fire Departments, or the Forest Service, depending upon which organization receives the fire report first. The agency having protection responsibility then follows through to complete the suppression and mopup. The Pine Ridge Civilian Conservation Center "hot shot crew" is available for backup on any fires within the area.

Weakness Illustrated

The weakness of decades-long fire management, which emphasized only control without corresponding fuel and vegetative management, was

Continued on next page

Robert W. Tice is a Recreation, Lands, and Fire Staff Officer with the Nebraska National Forest, Chadron, Nebr.

illustrated on September 2, 1976. Temperature at 1:00 p.m. was 95°F., with a relative humidity of 10 percent. Wind was 30 to 35 mi/hr from the west.

At about 10:30 a.m., a carryall transporting relief crews into a previously controlled fire broke a fan belt. Their leader proceeded to walk his crew into the old fire area. Upon returning to his vehicle at 11:20 a.m., he discovered that the carryall was on fire. Since no fire tools were available, he and his crew tried to combat the fire by beating it out with shirts. Fuel conditions at the point of origin were dry, cured grass. By 12:10 p.m., the fire had reached the trees. Control could not be established, and the fire soon crowned and moved rapidly due to the strong wind.

Assistance was requested from the Pine Ridge Civilian Conservation Center, Chadron State Park, and the fire departments of Chadron, Crawford, Hay Springs, Rushville, and Hemingford. A local crop-duster airplane dropped liquid fertilizer and water on the fire several times with little effect. A Forest Service contract air tanker dropped retardant twice during the afternoon with little effect. Efforts of the first arriving volunteer fire department were directed at keeping the fire from spreading into the adjacent grassy private lands.

Assistance

Requests for assistance were broadcasted by the news media. Response from the area citizens to the call for help was termed "tremendous" by firefighters at the scene. Farmers and ranchers provided tractors and other heavy equipment that could be used to help build fire lines.

Coordination Difficult

Coordination and supervision of the many casual volunteers who arrived to help fight the fire was difficult. In many cases they just grabbed hand tools and rushed to the fire lines without organization or supervision. At one point, up to 100 volunteers were on the fire lines.

Firefighters were assisted by many volunteers who were not counted, such as those who made sandwiches and transported them to the fire. Several four-wheel drive vehicles made many trips into the fire area delivering beverages, sandwiches, and other supplies that had been made by firefighters spouses and concerned members of the community.

Coordination was extremely difficult due to the mixture of personnel, lack of training for many persons and organizations, different radio frequencies, and so on. Nevertheless, the sheer force of the volunteers through the first night provided enough leeway for two interregional fire crews and two organized crews to man effectively the line by 6:00 a.m. the following morning.

The fire was rapidly controlled with the trained and experienced crews providing the organizational backbone around which the volunteers could better function. Fortunately no homes were destroyed and no lives were lost in the blaze.

Hot-Fire Analysis

A "hot-fire analysis" and a followup meeting with cooperating agencies and fire departments brought out the problems and opportunities for cooperative fire control in Nebraska.

Deficiencies in communication, training, organization, and overhead for handling and utilizing a mixture of individual volunteers and organizations were illustrated by the fire, and future needs for rapid and effective control were made clear.

Radio Communications Improved

The radio communication problems have been alleviated by the development of the Dawes County Communication System. This system provides communication to a four-county area in northwestern Nebraska for law enforcement, emergency medical service, and fire suppression activities. A central dispatching system allows for "patching in" of any system to another during emergencies. Five separate systems including the National Forest radio net allows more rapid communication during emergencies such as fire, tornadoes, and public disturbances.

Technical assistance has also been given the Chadron Volunteer Fire Department in the development of an adequate communication equipment maintenance schedule and contract.

In addition, three portable radios on the volunteer fire frequency are available for use on joint fires. Three small hand-held radios are now available for fire line communication.

Soliciting Volunteers

The local radio station has been cautioned against asking for volunteer firefighters until a responsible agency indicates the need for volunteers.

The most important development was implementing a cooperative agreement between the volunteer fire departments and the Forest Service. This agreement provides for the volunteer fire departments to take independent initial attack action on any fire regardless of landownership for up to 2 hours or until relieved by the Forest Service. For this action they are paid a lump sum at the beginning of the year. The speed of initial attack has been greatly accelerated on all lands because of this agreement.

Training Volunteers

Training in large-fire organization among the volunteers has never been done in Nebraska. The Nebraska Fire Training Service is planning to give training in large-fire organization and management to mutual-aid associations in Nebraska's panhandle.

Managing Fuels

Equally clear is the need for aggressive and effective fuel management in Nebraska to minimize the possibility of future fires like the Cunningham. The Nebraska Game and Parks Department and several private landowners are beginning to use prescribed fire on their lands to reduce fuels and increase forage production. This effort needs to be continued.

The people of Nebraska are quick to respond to an emergency because they know what fire can do, not only to themselves, but to their neighbors. Through training, better communications, and planning these potentially large fires can be kept small. The effort to date has been noteworthy. More coordination is expected in the future as a result of the Cunningham Fire on Nebraska's Pine Ridge.

Figure 1.—Ponderosa pine reproduction combined with accumulated ground fuels to provide a ladder for fire to reach the tree crowns.

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